Physics 11 Review for Thermal Energy, the Atom, and Nuclear Physics

1) 50.0g of ice at 0.00C is placed into 250.g of water at 10.0C.
    A) What is the starting temperature of the water in K?
    B) What is the energy required to melt all the ice? (water h_f = 3.34×10^5 J/kg)
    C) What is the energy required to change the temperature of the water to 0.00 C? (c = 4180 J/kg*C)
    D) How many mL of water will there be when the equilibrium temperature of 0 C is reached (1g = 1mL)

A)

K = 10.0 C + 273.15 = 283.15 K

B)

$$Q = mh_f = (0.0500kg)\left(3.34\text{x}10^5 \frac{J}{kg}\right) = 1.67\text{x}10^4 J$$

C)

$$Q = mc\Delta T = (0.250kg)\left(4180 \frac{J}{kg\ °\text{C}}\right)(10.0°\text{C} - 0.00°\text{C}) = 1.05x10^4 J$$

D)

Examining our answers above for B) and C) we can see that once we reach 0 C not all of the ice has melted because 1.67×10^4 J > 1.05×10^4 J. We can either calculate how much ice remains by taking the difference in energy between the answers for B) and C) or we can calculate how much ice has melted. Since we are looking for how many mL of water there will be at equilibrium I'll calculate how much ice has melted.

$$Q = mh_f = (m)\left(3.34\text{x}10^5 \frac{J}{kg}\right) = 1.05\text{x}10^4 J$$

$$m = 31.4\ g = 31.4\ mL$$

$$50\ mL + 31.4\ mL = 81.4\ mL$$

This means 18.6 g of ice remains

2)
    A) What is the difference between the half-life and the activity of ${}^{227}_{92}U$?
    B) ${}^{227}_{92}U$ has a half-life of 1.1 minutes. If a sample has an initial activity of $8.0 \text{ X } 10^6$ decays / second, how many minutes later will it have an activity of $5.0 \text{ X } 10^5$?
    C) If the sample had an initial activity of $8.0 \text{ X } 10^6$ decays, what would be the activity after 3.0 minutes?

    A) The time required for half of the atoms in any given quantity of a radioactive isotope to decay is the half-life of that element. The decay rate, or number of decays per second, of a radioactive substance is called its activity. Half life is a measure of time whereas activity is a measure of decays per second.

B)

$$N = N_o \left(\frac{1}{2}\right)^{\frac{t}{t_{1/2}}}$$

$$5.0x10^5 = 8.0x10^6 \left(\frac{1}{2}\right)^{\frac{t}{1.1}}$$

Solving the above equation can be quite difficult but if we recognize that $5.0x10^5$ / $8.0x10^6$= 1/16

And we know that $\frac{1}{16} = \left(\frac{1}{2}\right)^4$ then we can solve for t ... $\left(\frac{1}{2}\right)^4 = \left(\frac{1}{2}\right)^{\frac{t}{1.1}}$ .... t = 4.4minutes

C)

$$N = N_o \left(\frac{1}{2}\right)^{\frac{t}{t_{1/2}}}$$

$$N = 8.0x10^6 \left(\frac{1}{2}\right)^{\frac{3.0}{1.1}} = 1.2x10^6\ Decays\ per\ second$$

3) The mass of the $^{19}_{9}F$ nucleus is 18.9984032u (Mass of proton 1.00825u, Mass of neutron 1.008665u, 1 u converts to 931.49 MeV))

A) What is the nuclear mass defect of Fluorine?
B) What is the binding energy of Fluorine?

A) 9 protons and 10 neutrons
Mass of 9 protons + 10 neutrons = (9(1.00825u) + 10(1.008665u)) = 19.1609u
Nuclear mass defect = 18.9984032u – 19.1609 = - 0.162497u
B) Binding energy E = (931.49 MeV / u) * (- 0.162497u) = -151.364 MeV

4)

A) That the energy of an electron in an atom is quantized, was theorized in which Model of the atom? By whom?
B) Name a phenomenon that occurs on Earth that isn't quantized and explain why?

A) Bohr Model.
B) Energy of a Pendulum – if the energy of a pendulum was quantized the pendulum would only be able to oscillate with certain amplitudes.

5) Complete the reactions:

A) $^{238}_{92}U \rightarrow {}^{234}_{90}Th + {}^{4}_{2}He$ by alpha decay
B) $^{234}_{90}Th \rightarrow {}^{234}_{91}Pa + {}^{0}_{-1}e + {}^{0}_{0}\bar{v}$ by beta decay

6) How are neutrons in a reactor affected when:

A) The cadmium control rods are in a reactor?
B) A graphite moderator is used in a reactor?
C) A heavy water moderator is used in a reactor?

A) The cadmium control rods absorb neutrons and prevent the chain reaction.

B) Moderators slow down the neutrons, which makes them more likely to be absorbed and create reactions.

C) Same as B)

7) A tau and antitau particle of equal mass collide and annihilate releasing 5.71 x 10^{-10}J of gamma ray energy. What is the mass of the antitau particle? (Speed of light = 3.0 x 10^{8}) 3.17 x 10^{-27}kg)
* remember J = (kg m^2) / s^2 and there are TWO particles with equal mass

$$E = mc^2 = 5.71x10^{-10}J = 2m\,(3.0x10^8\frac{m}{s})^2$$

$$m = 3.2x10^{-27}kg$$

8) Protons and neutrons are made up of "up" quark (charge +3/2), and "down" quark (charge -1/3)

A) What three quarks make up a proton? Neutron?

B) What is the name of one type of Lepton Particle?

A) Proton is charge +1 so (3/2) + (3/2) + (-1/3) = up + up + down = +1
Neutron is charge 0 so (3/2) + (-1/3) + (-1/3) = up + down + down = 0

B) Electron, Muon, Tau, Electron neutrino, Muon neutrino, Tau neutrino

9) To purify gold and turn it into 12.4 kg (Troy ounce) bricks 12.4 kg of gold is heated up to 1064 C and completely melted into a mould. The melting point of gold is 1064 C. After the gold is heated and purified it is placed in 20L of water at 21.0 C to cool. (Gold: H_f 6.3 x 10^4 J/kg, H_v 1.64 x 10^6 J/kg, water c = 4180 J/kg*C, gold c = 130 J/kg*C)

A) What is the energy required to solidify the gold brick after melting?

B) Once the entire brick is solidified what is the temperature of the water? (1L = 1kg)

C) What is the temperature of the gold brick once thermal equilibrium with the water is reached?

A)

$$Q = mh_f = (12.4kg)\left(6.3\text{x}10^4\frac{J}{kg}\right) = 7.8\text{x}10^5 J$$

B)

$$Q = mc\Delta T = (20kg)\left(4180\frac{J}{kg\,°\text{C}}\right)\left(T_f°\text{C} - 21.0°\text{C}\right) = 7.8x10^5 J$$

$$T_f = 30.3$$

D) At thermal equilibrium the heat lost by the gold brick must equal the heat gained by the water

$$0 = mc\Delta T_{water} + mc\Delta T_{gold}$$

$$-mc\Delta T_{water} = mc\Delta T_{gold}$$

$$(20kg)\left(4180\frac{J}{kg\,°\text{C}}\right)\left(T_f°\text{C} - 30.3°\text{C}\right) = (12.4kg)\left(130\frac{J}{kg\,°\text{C}}\right)\left(T_f°\text{C} - 1064°\text{C}\right)$$

$$T_f = 49.9°\text{C}$$